THE CREATION OF A MOUNTAIN LAKE SPORTFISHERY AT CARDINAL RIVER COALS LTD.[1]

by

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Abstract. Cardinal River Coals, Ltd. produces 2 Million Clean Short Tons of metallurgical grade coking coal annually for the export market. The primary focus of reclamation at CRC, Ltd. is the development of wildlife habitat with particular emphasis on Rocky Mountain Bighorn Sheep. A secondary objective of recreational development has been applied in our 50-B-6 Area with the creation of a lake. Shoreline recontouring, littoral zone construction, macrophyte/plankton innoculation and habitat enhancement techniques have been utilized in an attempt to provide a viable sportfishery. Progress to date is being monitored by a continuing limnological study to determine rate of food chain development leading to recommendations for a sportfish stocking program.

Introduction

Cardinal River Coals Ltd. (CRC Ltd.) is an open pit coal mine located approximately 500 km (310 miles) northwest of Calgary. The operation has produced over 32 Million Clean Short Tons of metallurgical coking coal since its inception in 1969, most of which has been purchased by the Japanese for steel manufacture.

Initial reclamation activities began in 1971 focussing on the creation of wildlife habitat. Open grasslands adjacent to unreclaimed highwalls provide excellent habitat for the resident herd of Rocky Mountain Bighorn Sheep, which has grown to a maximum count of 281 individuals. Reforestation has been limited to areas where microsites are more conducive to wind protection and moisture retention; these areas will cater to deer/moose utilization.

Current reclaimed land use planning has expanded to include recreational use. The creation of a mountain lake sportfishery in the 50-B-6 Pit is one example of this diversification.

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Table 1

Morphometric Data for 50-B-6 Lake

	Metric	Standard
Volume	6.5M m^3	5,244 ac ft
Maximum Length	817 m	2,680 ft
Maximum Width	277 m	910 ft
Maximum Depth	100 m	328 ft
Mean Depth	44.6 m	146 ft
Shoreline Length	1944 m	6,380 ft
Area-Total	16.0 Ha	39.5 ac
-Littoral Zone	0.7 Ha	1.7 ac

Hydrological Planning

The 50-B-6 Pit (Table 1) was a deviation from the normal open pit mining technique employed at CRC Ltd. In most situations, a series of pits are planned along the strike of a coal structure where it nears the surface. Overburden from the initial pit is dumped externally; future excavations then backfill the previous pit. Internal phasing often allows partial backfilling of the final pit in the sequence.

The 50-B-6 Pit, however, was a single pit where coal removal was justified as a result of a small creek valley which reduced topography immediately above a section of the coal structure. The reclamation costs involved with rehandling sufficient overburden for backfill after mining to achieve the 27° final slope angle specified in our government approval would have been prohibitive. As the pit was located in a natural creek valley and water supply could be guaranteed, a decision to reclaim the pit as a lake was made at the outset, and approved by the government agency.

The proximity of mining at CRC Ltd. to the front ranges of the Rocky Mountains result in a number of small drainages passing through the site. Each of these basins respond immediately to precipitation events and, because the watershed is largely above treeline, low catchment factors coincide with high flow regimes. Luscar Creek and Jarvis Creek West both flowed through areas of future pit development and a diversion plan was required.

Luscar Creek contained a small lake within the drainage. This had been used as a water supply for the old townsite of Luscar between 1921 and 1955. CRC Ltd. installed a dam structure in the early 1970's to expand the size of Luscar Lake such that it could be utilized for domestic water use, coal processing and fire protection. This dam provided an opportunity for the flows of Luscar Creek to be diverted into Jarvis Creek West which would feed the completed 50-B-6 Lake. This extra flow greatly improved the filling and flushing rate in addition to offering a source of warmer water with a developed benthic and plankton base to innoculate the new lake.

Post Mining Construction

The most critical factor for the successful construction of a productive lake in the 50-B-6 Pit was the development of adequate littoral zone. These shallow areas would allow good light penetration for macrophytic growth and warmer water temperatures contributing to the establishment of a diverse and abundant lower food chain population. It was also important to make the shoreline of the lake accessible to recreational users.

In an open pit with overall wall angles of 50-55°, opportunity for shallow areas (3 metres of water or less) and approachable shorelines is somewhat limited. It was accomplished in the 50-B-6 area using various techniques. Resloping of backfilled overburden was required at the west end of the lake to achieve a 27° slope angle. Additional material was carried to final water level to create a small terrace. The extra cost to move the material was unjustified, however, as much of the terrace was lost to settlement after innundation. A safety bench on the north highwall, 8 metres (26 ft) in width, also provided some useable shallow area which continues to function as a littoral zone.

The south and east sides of the pit wall contained a wide bench which had been constructed to carry the flows of Jarvis Creek West in a 48" culvert during the period of active mining. A pit bottom access ramp immediately below the bench provided an excellent catchment area for overburden material so a blast casting technique was utilized to reduce the slope to the final shoreline in this area. A BE45R production drill was utilized to drill 27 cm (10-5/8 in) holes on a 4.6 m by 9.2 m (15 ft x 30 ft) spacing and was loaded with Anfo blasting agent to a powder factor of about 1.3. Holes were drilled to a subgrade of 3 m (10 ft) below the 27° final contour.

A total of 124,887 BCM (163,337 BCY) were blasted at a cost of $.29 BCM ($.38 BCY) for a total cost of $62,068. Komatsu 355 dozers were then utilized to grade the material to the final 2:1 slope angle such that topsoil material could be applied. This drill/blast/reslope technique is the most cost effective method of achieving the required 27° final slope angle and will be used in the reclamation of many future pit highwalls.

The majority of the littoral area of the 50-B-6 Lake was constructed at the east end where the lake water exits to the natural channel of Jarvis Creek West. D9L dozers were used to excavate a 0.57 Ha (1.4 ac) area in the downstream gravels and move the material into the pit. Final water depth within the basin averages 1 m (3.3 ft). A berm was constructed to final water elevation to separate the warmer more productive shallow area from the main body of the lake which also serves to intercept the heavy wave action during windy periods.

In each of these mini projects for littoral zone creation, intensive surveying was required to ensure good elevation control. Continuous laser monitoring proved to be an excellent method as it allowed the equipment operators to control elevation as construction proceeded.

A total area of 0.70 Ha (1.73 ac) of littoral zone was developed. Although this constitutes only about 5% of the total lake surface area, further development would have involved placement of backfill at a prohibitive cost. The remedial work done provided shallow area over 36% of the lake perimeter and accessible approach to 44% of the shoreline.

Soil material was spread on recontoured areas above water level as well as on some littoral zone and revegetated with a diverse grass/legume mixture. In addition, highwalls on the north side were seeded by helicopter and have shown an impressive catch. Bighorn sheep and mule deer regularily utilize the lake area.

Habitat Enhancement

Development of the lake included some enhancements to improve the fishery potential. A number of large truck tires were placed on the shallow safety bench area. These tires measure approximately 3 m (10 ft) in diameter and offer a substantial surface area for periphyton attachment. They also have a large internal area which fish may utilize similar to an overhanging bank in a stream environment. These artificial reefs will increase feeding potential within that area of the lake and should a deep water species such as Lake Trout (Salvelinus namaycush) be introduced at a later date, may also be utilized for spawning.

The littoral zone at the outflow and along the southeastern edge of the lake was topdressed with organic soil such that these areas could support a strong macrophytic plant community. Partially decomposed hay was "walked into" the soil with a small dozer to further increase the organic content and offer suitable benthic invertebrate habitat. An experimental macrophyte innoculation program was then initiated from a natural lake near the site. Special barrels were fabricated which were filled with underwater plant material and detritus from the natural lake and transported by helicopter to the 50-B-6 area to be spread in the shallows. Pondweed (Potamogeton richardsonii and P. vaginatas) and Northern Watermilfoil (Myriophyllum exalbescens) were the predominant species and preliminary results indicate good survival and growth rates. A further transplant program is planned for spring of 1989.

Prior to mining, fisheries monitoring in Jarvis Creek West showed strong seasonal use of Rainbow trout (Salmo gairdneri) relative to other small tributaries in the immediate area. Resident adults, juveniles and young of the year were represented and spawning was observed. In an attempt to improve the spawning potential immediately downstream of the lake, a habitat improvement program was undertaken in the late summer of 1987. A gabion mat with geotexile underlay was installed at the outflow of the lake to ensure a constant water level. A plunge pool was excavated to a 4 m (13 ft) depth immediately below the mat which then fed the original stream channel. Small step dams were constructed on 8 m (26 ft) intervals along the stream by installing logs extending across the bed and keyed into the bank on each side. Fine washed gravel was placed behind each dam to a depth of 15-20 cm (6-8 in). The action of the water creates a small pool immediately below each dam with fresh aerated water upwelling through the washed gravel at the tail of the pool which is held in place by the next dam. This technique was used in a repeating fashion for a total of 75 m (250 ft) downstream interrupted by an additional two large pools excavated to a minimum depth of 4 m (13 ft). Rainbow and Brook trout (Salvelinus fontinalis) were observed during the summer of 1988 moving upstream through the step dams and into the lake. Spawning is expected to occur as early as spring of 1989.

Limnological Investigations

Two limnological studies have been conducted to date on 50-B-6 Lake. The first (R.L. & L. 1987) was undertaken in 1986 while the lake was filling and included surveys at the end of July and in early October. Shoreline erosion and constant turbulence as a result of methane released from the coal caused the water to be very turbid yielding Secchi disc measurements of less than 0.3 m (1 ft). The lake had stratified by mid-summer with a distinct thermocline at 6-7 m (20 ft) below which oxygen was severely depleted. High levels of nitrogen and phosphorous were observed and concern was expressed about a possible algal bloom and related biological oxygen demand. Benthic invertebrates were limited to a very small number of midge larvae which are generally the primary colonizers. Zooplankton levels were similarly low with a few cladocerans (Daphnia pulex) appearing in the fall survey. Phytoplankton diversity was surprisingly high but densities very low despite high nutrient levels; the limited light penetration in the turbid water resulted in low Chlorophyll A values.

The second survey (Pisces 1989) was conducted during the spring and fall of 1988. The lake had reached full supply level and outflow commenced on October 6, 1987. By June 22, 1988 water clarity was excellent with Secchi disc transparency to 4.1 m (13.5 ft). No further turbulence was observed; the weight of the water and the deposited sediment has apparently sealed the coal from further methane release. Thermal stratification was apparent at 8-9 m (26-30 ft) with oxygen depletion at depths below 15 m (50 ft). Phosphorous levels had significantly decreased to well within Alberta Surface Water Quality Objectives but nitrogen remained high. This is a common situation at the minesite and is a result of the use of Ammonium Nitrate/Fuel Oil as a blasting agent. Providing phosphorous continues to be the limiting factor, high nitrates were not considered a problem and would likely contribute to a more productive alpine lake. Phytoplankton density was much improved and is now comparable to natural lakes in the area, however, diversity was reduced from the previous survey with Coccochloris sp., the dominant genus. Zooplankters were again predominantly Daphnia pulex. It was interesting that the percentage of these individuals greater than 1 mm in length increased from less than 10% in June, to 33% in September, to 97% in January of 1989. Total biomass was estimated at 0.495 mg/lit. Dipteran populations had dramatically increased since the initial survey, however, with the exception of a few valvatid snails, they were the only benthic invertebrates represented.

The 50-B-6 Lake has demonstrated substantial improvement in water quality and biological productivity over the past two years. Although final fishery success will be restricted by the limited littoral zone available, the proposed end use of a recreational fishery is achievable. Further improvements may be implemented to speed the establishment of the biological community.

Future Plans

Physical enhancements in the 50-B-6 Lake area are very near completion. Soil material will be placed and seeded in a small section at the west end and a maintenance fertilization program on the revegetated areas will be carried out. One further idea which will be investigated is the installation of a pipeline operated during the summer seasons to siphon deoxygenated water from the profundal zone and release downstream. This would serve to reduce the volume of productive water lost to outflow resulting in an increase in above-thermocline temperatures and a deeper oxygenated zone.

A number of biological improvements will be implemented through the summer of 1989. Additional volumes of particially decomposed hay will be placed in the littoral zone at the lake outflow. As a result of the apparent success of last years program, further macrophyte transplants will be undertaken. Transplants of benthic invertebrates will also be conducted, focussing on amphipods such as Gammarus lacustris and Hyalella azteca which are easily accessible in local ponds and lakes. Consideration is also being given to the introduction of Opossum shrimp

(Mysis relicta) which is indigenous to deep cold lakes and can be an important food chain component in a trout fishery.

In an attempt to diversify and intensify the phytoplankton population, water will be taken from a local lake and stored in the sunlight in a transparent tank. Light additions of water soluable fertilizer and aeration over a 4-6 day period should produce a good introductory stock for release to the lake. Controlled phosphorous applications to the lake itself will then encourage population expansions within the waterbody.

Fish stocking is currently scheduled for 1989 and will supplement the influx of native Rainbow (Salmo gairdneri Athabasca), Brook Trout, and Dolly Varden (Salielinus malma) which have moved upstream from the Macleod River System. Estimates for annual fish production potential range from 1.90 to 8.75 kg/ha (1.69 to 7.79 lb/ac) which favourably compares to the average of 6.5 kg/ha (5.79 lb/ac) for 46 high mountain lakes in Alberta (Radford 1979). In the 50-B-6 lake, cladocerans over 1 mm (0.04 in) in length formed the bulk (>85%) of available fish food. This source would be most efficiently utilized by Cutthroat trout (Salmo clarki), however, local Fish and Wildlife authorities indicate a preference toward the native Rainbow to prevent hybridization of this strain. The presence of Brook trout and Dolly Varden in Jarvis Creek West may suggest the genetic purity has already been compromised. Initial stocking rates for Rainbow would be in the range of 75-85 fingerlings per hectare (30-35 per acre) with cautious maintenance stocking until natural reproduction rates can be evaluated.

Public access will be permitted by 1992 provided future monitoring of the lake confirms viable fishery production. A foot or ATV access initially will prevent overfishing and immediate depletion of the stocked population.

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